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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:

André MAARTENS et al.

Serial No.: 10/090,802

Filed: March 6, 2002

For: **A MONITORING UNIT FOR
MONITORING THE CONDITION OF
A SEMI-PERMEABLE MEMBRANE**

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) Group Art Unit: 1724
)
) Examiner: Not Yet Assigned
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**Assistant Commissioner for Patents
Washington, DC 20231**

Sir:

CLAIM FOR PRIORITY

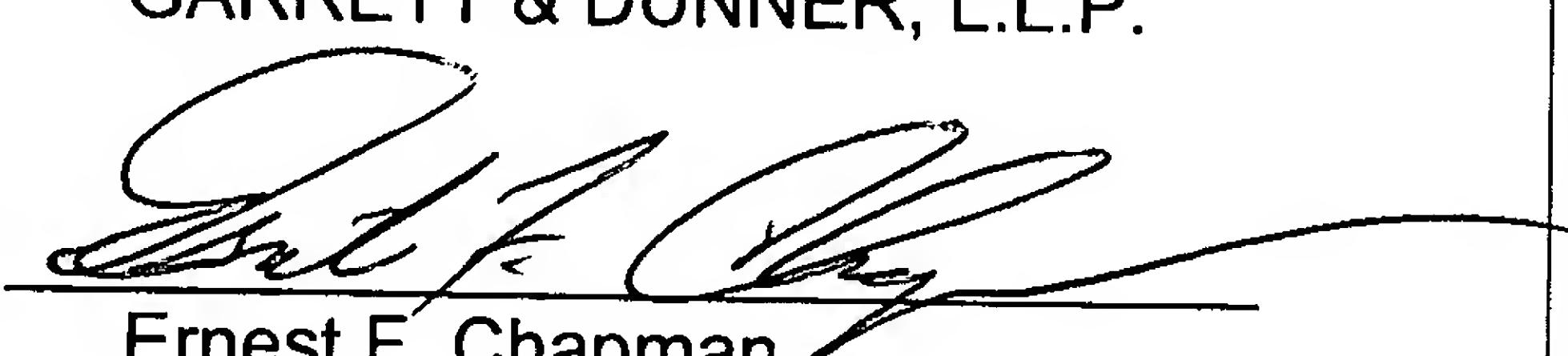
Under the provisions of 35 U.S.C. § 119, Applicants hereby claim the benefit of the filing date of South African Patent Application No. 2001/1855, filed March 6, 2001, for the above-identified U.S. patent application.

In support of this claim for priority, enclosed is one certified copy of the priority application.

Respectfully submitted,

FINNEGAN, HENDERSON, FARABOW,
GARRETT & DUNNER, L.L.P.

Dated: June 6, 2002

By: 
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Sertifikaat

PATENTKANTOOR
REPUBLIC OF SOUTH AFRICA



Certificate
PATENT OFFICE
REPUBLIEK VAN SUID-AFRIKA

DEPARTEMENT VAN HANDEL
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DEPARTMENT OF TRADE AND
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Hiermee word gesertifiseer dat
This is to certify that



- 1) South African Provisional Patent Application No. 2001/1855 accompanied by a Provisional Specification was filed at the South African Patent Office on the 6 March 2001, in the name of Sasol Technology (Pty) Limited in respect of an invention entitled: "Monitoring unit for use in a osmosis water purification system".
- 2) The photocopy attached hereto is a true copy of the provisional specification and drawings filed with South African Patent Application No. 2001/1855.

Geteken te
Signed at

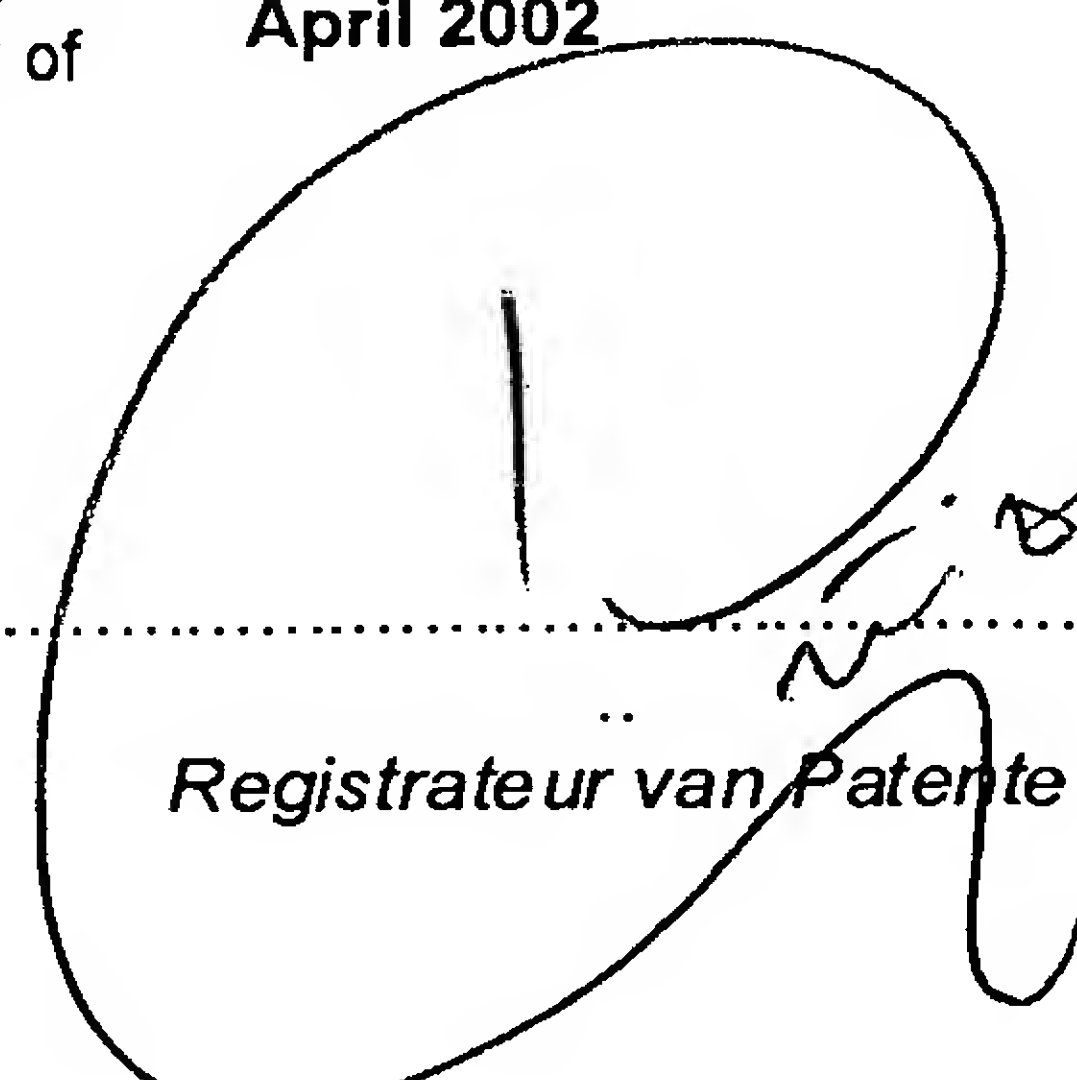
PRETORIA

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in the Republic of South Africa, this

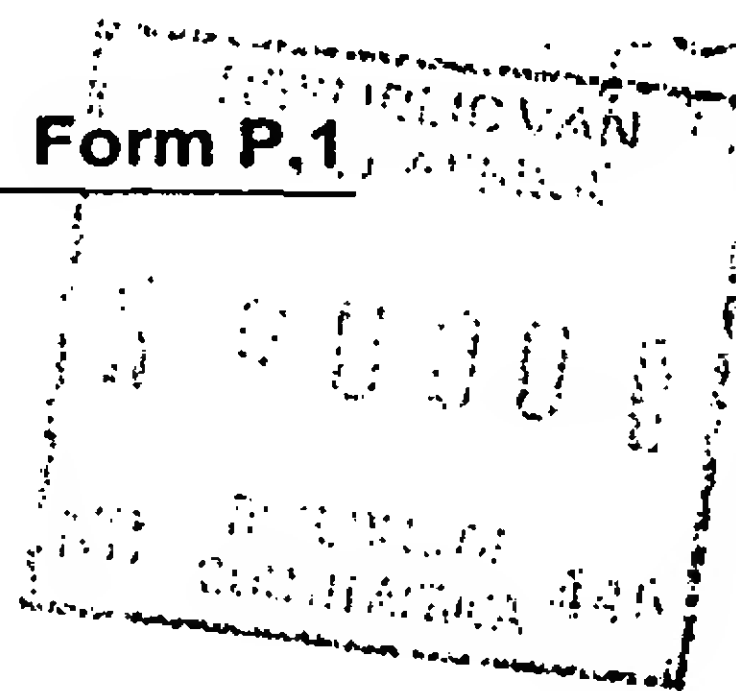
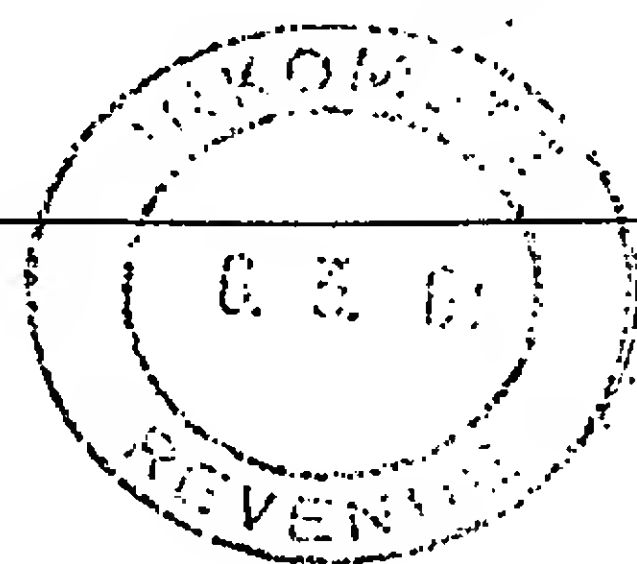
5th

dag van
day of

April 2002


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Registrateur van Patente

REPUBLIC OF SOUTH AFRICA				PATENTS ACT, 1978			
REGISTER OF PATENTS							
OFFICIAL APPLICATION NO.			LODGING DATE : PROVISIONAL			ACCEPTANCE DATE	
21	01	2001/1855	22	25 April, 2001		43	
INTERNATIONAL CLASSIFICATION			LODGING DATE : COMPLETE			GRANTED DATE	
51			23				
FULL NAME(S) OF APPLICANT(S) / PATENTEE(S)							
71	SASOL TECHNOLOGY (PTY) LIMITED						
APPLICANTS SUBSTITUTED :						DATE REGISTERED	
71							
ASSIGNEE(S)						DATE REGISTERED	
71							
FULL NAME(S) OF INVENTOR(S)							
72	MAARTENS, André JACOBZ, Edmund Petrus PEET, Douglas AUGUSTYN, Maria Petronella						
PRIORITY CLAIMED		COUNTRY		NUMBER		DATE	
N.B. Use international abbreviation for country. (See Schedule 4)		33		31		32	
TITLE OF INVENTION							
54	MONITORING UNIT FOR USE IN A REVERSE OSMOSIS WATER PURIFICATION SYSTEM						
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74	D M Kisch Inc, 66 Wierda Road East, Wierda Valley, SANDTON					P21348ZA00	
PATENT OF ADDITION NO.			DATE OF ANY CHANGE				
61							
FRESH APPLICATION BASED ON			DATE OF ANY CHANGE				



APPLICATION FOR A PATENT AND ACKNOWLEDGEMENT OF RECEIPT
(Section 30 (1) - Regulation 22)
The grant of a patent is hereby requested by the undermentioned applicant on the basis of the present application filed in duplicate.

OFFICIAL APPLICATION NO		
21	01	20011855

DMK REFERENCE
P21348ZA00

FULL NAME(S) OF APPLICANT(S)	
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71	SASOL TECHNOLOGY (PTY) LIMITED
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ADDRESS(ES) OF APPLICANT(S)	
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	1 Klasie Havenga Sasolburg SOUTH AFRICA
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TITLE OF INVENTION	
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54	MONITORING UNIT FOR USE IN A REVERSE OSMOSIS WATER PURIFICATION SYSTEM
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	THE APPLICANT CLAIMS PRIORITY AS SET OUT ON THE ACCOMPANING FORM P2 The earliest priority claimed is
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	THIS APPLICATION IS FOR A PATENT OF ADDITION TO PATENT APPLICATION NO.	21	01	
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	THIS APPLICATION IS FRESH APPLICATION IN TERMS OF SECTION 37 AND BASED ON APPLICATION NO.	21	01	
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THIS APPLICATION IS ACCOMPANIED BY :	
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<input checked="" type="checkbox"/>	1a	A single copy of a provisional specification of 19 pages.	
<input type="checkbox"/>	1b	Two copies of a complete specification of pages.	
<input type="checkbox"/>	2a	Informal drawings of sheets.	
<input checked="" type="checkbox"/>	2b	Formal drawings of 3 sheets.	
<input type="checkbox"/>	3	Publication particulars and abstract (form P8 in duplicate).	
<input type="checkbox"/>	4	A copy of figure of the drawings for the abstract.	
<input type="checkbox"/>	5	Assignment of invention (from the inventors) or other evidence of title.	
<input type="checkbox"/>	6	Certified priority document(s).	
<input type="checkbox"/>	7	Translation of priority document(s).	
<input type="checkbox"/>	8	Assignment of priority rights.	
<input type="checkbox"/>	9	A copy of form P2 and a specification of S.A. Patent Application.	21 01
<input type="checkbox"/>	10	A declaration and power of attorney on form P3.	
<input type="checkbox"/>	11	Request for ante-dating on form P4.	
<input type="checkbox"/>	12	Request for classification on form P9.	
<input type="checkbox"/>	13a	Request for delay of acceptance on form P4.	
<input type="checkbox"/>	13b		

DATED 6 March, 2001

ADDRESS FOR SERVICE	
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Patent Attorney for Applicant(s) REGISTRAR OF THE COURT OF PATENTS COMMISSIONER OF PATENTS RECEIVED	
OFFICIAL DATE STAMP 2001-03-06	
REGISTRAR OF PATENTS PATENTS OFFICE REPUBLIC OF SOUTH AFRICA	

The duplicate will be returned to the applicant's address for service as proof of lodging but is not valid unless endorsed with official stamp.

REPUBLIC OF SOUTH AFRICA

PATENTS ACT, 1978

PROVISIONAL SPECIFICATION
(Section 30 (1) - Regulation 27)

OFFICIAL APPLICATION NO.			LODGING DATE		DMK REFERENCE
21	01	2001/1855	22	6 March, 2001	P21348ZA00

FULL NAME(S) OF APPLICANT(S)	
71	SASOL TECHNOLOGY (PTY) LIMITED

FULL NAME(S) OF INVENTOR(S)	
72	MAARTENS, André JACOBZ, Edmund Petrus PEET, Douglas AUGUSTYN, Maria Petronella

TITLE OF INVENTION	
54	MONITORING UNIT FOR USE IN A REVERSE OSMOSIS WATER PURIFICATION SYSTEM

Introduction

This invention relates to an apparatus for monitoring performance of a water purification system. Particularly, the invention relates to a monitoring unit or test cell for monitoring fouling and biofouling of semi-permeable reverse osmosis membranes utilized in water purification systems. The invention also extends to the use of such a monitoring unit in evaluating various operating parameters of such a system, and to a water purification system including such a monitoring unit or test cell.

Background to the invention

Those who are familiar with the industry will appreciate that a reverse osmosis water purification system provides for cleaning impure aqueous solution by forcing the solution through a semi-permeable membrane to obtain a substantially pure aqueous solution. More particularly, an impure aqueous solution is generally pumped, under pressure, through the semi-permeable membrane, which is designed for retaining impurities such as organic and inorganic substances, thereby effecting passage only of the substantially pure aqueous solution through the membrane.

The life span of such a reverse osmosis water purification system is largely dependent on the efficiency of the semi-permeable membrane. Over a period

of time, the membrane's efficiency decreases due to adsorption of impurities on the membrane surface. Moreover, uncontrolled microbiological growth in a feed fluid tank, pipelines or on the membranes themselves can result in severe biofouling of the semi-permeable membrane. If this situation is detected in time, the membranes can be cleaned, for example by mechanical or chemical treatment. However, a major problem associated with this type of technology is

the lack of methodology by which fouling or biofouling of the membrane is detected and monitored. If the membrane is not cleaned in time, the membrane can be damaged permanently, unavoidably resulting in down-time of the system, associated production losses, and expensive maintenance and replacement costs for replacing the membrane.

Existing apparatus for detecting fouling of the semi-permeable membrane depend mainly on changes in fluid pressure or permeate flux of the membrane system. The major disadvantage associated with existing apparatus is that they are often not sensitive enough for detecting fouling of the membrane in time, the situation being such that by the time fouling is eventually detected, the membrane is already damaged.

Object of the invention

It is accordingly an object of the present invention to provide a novel apparatus for monitoring the condition of a semi-permeable membrane, especially of the type utilized in a reverse osmosis water purification system, that will overcome or at least minimize some of the disadvantages associated with known apparatus of this kind.

It is a further object of the invention to provide for use of such an apparatus for evaluating and comparing different operational parameters of a reverse osmosis water purification system.

It is yet a further object of the invention to provide a water purification system including the novel apparatus for monitoring the condition of a semi-permeable membrane.

Summary of the invention

According to the invention there is provided a monitoring unit for monitoring the condition of a semi-permeable membrane, the monitoring unit comprising

a flow chamber having an inlet for permitting ingress of a feed fluid into the flow chamber, the arrangement being such that the membrane is at least partly supported in the flow chamber;

at least one fluid outlet arranged in fluid communication with the flow chamber for permitting egress of fluid from the monitoring unit after having passed through the membrane; and

an inspection window for permitting visual inspection of the semi-permeable membrane.

The monitoring unit particularly may be adapted for monitoring fouling of the semi-permeable membrane. For the purpose of this specification, "fouling" will be interpreted to include organic fouling, inorganic fouling, bio-fouling or the like accretion of impurities such as precipitates, scale or the like particulate matter on a surface of the semi-permeable membrane. Furthermore, the term "feed fluid" will be interpreted to mean substantially impure fluid introduced into the flow chamber, whereas the term "fluid" will mean substantially pure fluid having passed through the semi-permeable membrane and exiting the monitoring unit.

The flow chamber may include a feed fluid outlet for permitting at least partial through-flow of the feed fluid through the flow chamber. In particular, cross-

flow conditions may apply in the flow chamber. The flow chamber may be dimensioned such that a fluid pressure interval is defined intermediate the feed fluid inlet and the feed fluid outlet. Particularly, fluid pressure at the feed fluid outlet may be less than that at the feed fluid inlet, the arrangement being such that, in use, the feed fluid partly exit through the feed fluid outlet of the flow chamber, and in part pass through the semi-permeable membrane.

The monitoring unit also may comprise a fluid permeable support member for supporting the semi-permeable membrane in the flow chamber. The support member may constitute a base portion of the flow chamber, the arrangement being such that feed fluid entering the flow chamber pass at least in part through the support member. The support member may be of any suitable porous material such as high-density polyethylene, stainless steel, brass, finely woven fiber or the like. The support member may include pores of pore sizes between 10 and 150 μm .

The monitoring unit further may include spacer means for spacing the semi-permeable membrane from the support member so as to provide a flow space between the membrane and the support member, or between adjacent membranes on the support member. The monitoring unit may accommodate different spacers that vary in thickness and shape, the arrangement being such

that different spacers influence fluid dynamics of the feed fluid flowing across the semi-permeable membrane. So, for example, the monitoring unit may include a spacer that is locatable intermediate the semi-permeable membrane and the support member that is similar to a permeate-side spacer generally used in construction of spiral wrap elements. Also, for example, the monitoring unit may include a feed-side spacer similar to that used in construction of spiral elements in use, wherein the feed-side spacer may be locatable on top of the semi-permeable membrane. It will be appreciated that specific spacer configurations affect the adsorption kinetics of fouling substances in the feed fluid and since the monitoring unit has the potential to include different types of spacers, it includes the expanded potential for using the same to evaluate spacer technology.

The fluid outlet may be arranged in fluid communication with the support member, the arrangement being such that fluid that has passed through the membrane and the support member exits the monitoring unit through the fluid outlet. The fluid outlet may be arranged in fluid communication with a suitable conduit for passing the fluid through the water purification system.

The inspection window may be oriented substantially parallel to and somewhat spaced from the support member, the arrangement being such that the flow

chamber is defined intermediate the support member and the inspection window. The inspection window may be of any suitable transparent material, such as plastics, Perspex, glass or the like, and may be characterized therein that it can withstand a pressure of at least between 40 and 50 bar.

The monitoring unit may include regulating means for regulating flow across the membrane, as well as fluid pressure in the unit. Particularly, the regulating means may be at least one valve suitably arranged for regulating the fluid pressure interval intermediate the feed fluid inlet and the feed fluid outlet. In one form of the invention, the monitoring unit may include at least one feed fluid inlet valve operatively associated with the feed fluid inlet. The monitoring unit also may include a feed fluid outlet valve operatively associated with the feed fluid outlet of the flow chamber. It is envisaged that the fluid outlet adjacent the support member also may include a suitable fluid outlet valve.

In use, the regulating means may permit repeatable or standard conditions, such as a constant cross-flow velocity and fluid pressure. By maintaining flow and pressure constant through the monitoring unit, flux or passage of pure water through the semi-permeable membrane can be measured. Any deviation in the flux through the membrane can then be attributed to adsorption of

impurities onto the membrane (fouling or biofouling), which changes the permeability characteristic of the membrane.

In one form of the invention, the monitoring unit may operatively be associated with pumping means for further manipulating fluid pressure in the monitoring unit. More particularly, the monitoring unit may operatively be associated with a positive displacement pump arranged in-line with the monitoring unit and suitable for maintaining the fluid pressure interval intermediate the feed fluid inlet and outlet of the flow chamber.

The monitoring unit further may include flow distribution means. The flow distribution means may be in the form of a manifold dimensioned for preventing turbulence within the flow chamber and for effecting homogenous fluid flow. In one form of the invention, the monitoring unit may include an inlet manifold arranged intermediate the feed fluid inlet and the flow chamber for regulating flow of feed fluid into the flow chamber.

The monitoring unit also may include an outlet manifold located intermediate the flow chamber and the feed fluid outlet. The outlet manifold may be arranged such that it prevents areas of decreased flow in the flow chamber, so as to prevent preferential foulant adsorption or biological growth. The

manifolds also may be arranged so as to permit reverse flow through the monitoring unit for evaluating the effectiveness of back flushing on removal of impurities adsorbed onto the membranes.

The monitoring unit further may comprise a casing. The casing may include top cover means and bottom cover means that releasably may be connected to each other in fluid-tight and pressure-tight engagement, the arrangement being such that the inspection window, flow chamber and support member are located substantially intermediate the top and bottom cover means. The casing may be of stainless steel or the like suitable material.

The top cover means may comprise a metallic frame dimensioned so as at least partially to frame the inspection window. The bottom cover means may comprise a metallic sheet recessed at least partially to accommodate the flow chamber, the support member and the fluid outlet.

The monitoring unit may be adapted for monitoring fouling of a semi-permeable membrane during operation of a water purification system. In particular, the monitoring unit may be characterized therein that it comprises the potential of simulating conventional fluid dynamics associated with these types of membranes across the spacer means and support member.

Consequently, the monitoring unit may be dimensioned such that conventional operating conditions of the water purification system are simulated in the monitoring unit. Particularly, the monitoring unit may operate at a fluid pressure corresponding to that of the water purification system. More particularly, the monitoring unit may operate at a fluid pressure of between 40 and 50 bar.

The monitoring unit may be located inline with a conventional reverse osmosis water purification system. The monitoring unit particularly may be adapted for monitoring fouling of a semi-permeable spiral membrane in a spiral reverse osmosis water purification system. In this form of the invention, the monitoring unit may be located intermediate a feed fluid tank and a spiral membrane plant of the spiral reverse osmosis water purification system.

According to another aspect of the invention there is provided a method of monitoring fouling of a semi-permeable membrane in a water purification system, the method comprising the steps of

- providing a monitoring unit according to the invention;
- placing at least one semi-permeable test membrane on the fluid permeable support member;
- effecting at least partial passage of feed fluid through the test membrane; and

visually monitoring fouling of the test membrane through the inspection window as an indicating means for determining fouling of the semi-permeable membrane in the water purification system.

The method may concern monitoring fouling of the semi-permeable membrane during operation of the water purification system. Consequently, the method may comprise the step of effecting at least partial passage of feed fluid through the membrane under conventional system operating conditions. The method particularly may concern monitoring fouling of a semi-permeable spiral membrane in a spiral reverse osmosis water purification system.

The test membrane may removably be placed on the support member. The test membrane may be spaced from the support member by means of spacer means.

The test membrane may be any suitable flat-sheet semi-permeable membrane, such as a micro-filtration, ultra-filtration, nanno-filtration or the like reverse osmosis membrane. In particular, any type of flat-sheet semi-permeable membrane associated with a polymeric support material may be used in the monitoring unit. Different types of polymeric materials used for the construction of these membranes may be used.

Fouling of the test membrane also may be monitored by means of suitable monitoring equipment, such as by means of laser beam or infra red refraction, or sound acoustics.

According to yet a further aspect of the invention there is provided the use of a monitoring unit including a semi-permeable test membrane for evaluating one or more of the following operating parameters in a water purification system

namely -

the efficiency of different types of chemicals utilized in the system, such as anti-

scalants, biocides and anti-fouling chemicals;

the effect of using different membranes and/or associated spacer means in the water purification system on the operating efficiency of the system; and efficiency of different membrane cleaning methods.

According to yet another aspect of the invention there is provided the use of a monitoring unit according to the invention for evaluating one or more of the following parameters in a spiral membrane reverse osmosis water purification system namely -

fouling of the spiral membrane;

the efficiency of different types of chemicals utilized in the system, such as anti-scalants, biocides and anti-fouling chemicals;

the effect of using different membranes and/or associated spacer means in the water purification system on the operating efficiency of the system; and efficiency of different membrane cleaning methods.

According to yet a further aspect of the invention there is provided a water purification system including at least one water-cleaning unit, the water purification system characterized therein that it includes a monitoring unit that comprises -

- a flow chamber having an inlet for permitting ingress of a feed fluid into the flow chamber;
- a fluid permeable support member for supporting the semi-permeable membrane in the flow chamber;
- at least one fluid outlet arranged in fluid communication with the support member for permitting egress of fluid from the monitoring unit after having passed through the membrane; and
- an inspection window for permitting visual inspection of the semi-permeable membrane in use supported by the support member.

According to yet a further aspect of the invention there is provided the use of a monitoring unit according to the invention in a water purification system.

Specific embodiment of the invention

Without limiting the scope thereof, one embodiment of the invention will now be described by way of example only and with reference to the accompanying drawings wherein –

Figure 1 is a cross-sectional side view of a monitoring unit according to one embodiment of the invention;

Figure 2 is a plan view of the monitoring unit of Figure 1; and

Figure 3 is a perspective view of the monitoring unit of Figures 1 and 2.

A monitoring unit according to the invention is generally designated by reference numeral 10. The monitoring unit 10 is adapted for use in a water purification system (not shown) that includes at least one water-cleaning unit, the water-cleaning unit comprising at least one membrane for cleaning water through reverse osmosis. Particularly, the monitoring unit 10 is adapted for monitoring the condition of a semi-permeable spiral membrane in a spiral membrane reverse osmosis water purification system by monitoring fouling of a semi-permeable test membrane 24 in the monitoring unit 10. It will be appreciated by those engaged in the industry that such a reverse osmosis water purification system often includes a series of successive water-cleaning units.

The monitoring unit 10 comprises a flow chamber 12 having a feed fluid inlet 14 for permitting ingress of a feed fluid into the flow chamber 12 and a feed fluid outlet 22 for permitting at least partial through-flow of the feed fluid through the flow chamber 12.

The flow chamber 12 is dimensioned such that a fluid pressure interval is defined intermediate the feed fluid inlet 14 and the feed fluid outlet 22. Particularly, fluid pressure at the feed fluid outlet 22 is less than that at the feed fluid inlet 14, the arrangement being such that, in use, feed fluid partly exits through the feed fluid outlet 22 of the flow chamber 12, and in part passes through the semi-permeable test membrane 24.

The monitoring unit 10 also comprises a fluid permeable support member 16 for supporting the semi-permeable test membrane 24 in the flow chamber 12.

The support member 16 is located in a stainless steel bottom plate 17 in which a receiving aperture is machined for receiving the support member 16 in use.

The support member 16 is arranged in fluid communication with a fluid outlet 18 for permitting egress of fluid from the monitoring unit 10 after having passed through the membrane. The support member 16 is a substantially porous member constituting a base portion of the flow chamber 12. In

particular, the arrangement is such that feed fluid entering the flow chamber 12 passes at least in part through the support member 16.

The semi-permeable test membrane 24 is spaced from the support member 16 by means of a number of intermediate spacers (not shown). In particular, the test membrane 24 has an exposed surface area of approximately $10\text{cm} \times 30\text{cm}$.

The monitoring unit 10 further comprises an inspection window 20 for permitting visual inspection of the semi-permeable test membrane 24 in use supported by the support member 16. The inspection window 20 is oriented substantially parallel to and somewhat spaced from the support member 16, the arrangement being such that the flow chamber 12 is defined intermediate the support member 16 and the inspection window 20. The inspection window 20 is a sheet of any suitable transparent material, such as plastics, Perspex, glass or the like characterized therein that it is capable of withstanding a pressure of between 40 to 50 bar.

The support member 16 is arranged in fluid communication with a fluid outlet 18 which is located in the bottom plate 17, the arrangement being such that fluid that has passed through the test membrane 24 and the support member 16 exits the monitoring unit 10 through the fluid outlet 18. The fluid outlet 18

is arranged in fluid communication with a suitable conduit (not shown) for passing the fluid through the water purification system.

The monitoring unit 10 further includes regulating means for regulating fluid pressure in the monitoring unit 10. Particularly, the regulating means is a valve suitably arranged for regulating the fluid pressure interval intermediate the feed fluid inlet 14 and outlet 22. In one form of the invention, the monitoring unit 10 includes at least one feed fluid inlet valve (not shown) operatively associated with the feed fluid inlet 14. The monitoring unit 10 also includes a feed fluid outlet valve (not shown) operatively associated with the feed fluid outlet 22 of the flow chamber 12.

The monitoring unit 10 further includes flow distribution means 28. The flow distribution means 28 is in the form of a manifold dimensioned for preventing turbulence within the flow chamber 12 and for effecting homogenous fluid flow. In the illustrated embodiment of the invention, the monitoring unit 10 includes an inlet manifold 28.1 arranged intermediate the feed fluid inlet 14 and the flow chamber 12 for regulating flow of feed fluid into the flow chamber 12. The monitoring unit 10 also includes an outlet manifold 28.2 located intermediate the flow chamber 12 and the feed fluid outlet 22.

The monitoring unit 10 further comprises a casing including top cover means 30 and bottom cover means 32 that are releasably connected to each other in fluid-tight and pressure-tight engagement by means of bolts 34 extending from the bottom cover means 32 and protruding through the top cover means 30. At one end thereof the bolts 34 are secured in place by means of washers 36 and nuts 38 dimensioned to accommodate the bolts 34. In particular, the arrangement is such that the inspection window 20, flow chamber 12 and support member 16 are located intermediate the top cover means 30 and bottom cover means 32. The casing is of stainless steel or the like suitable material.

The top cover means 30 comprises a metallic frame dimensioned so as at least partially to frame the inspection window 20. The bottom cover means 32 comprises a metallic sheet recessed at least partially to accommodate the support member 16 and the fluid outlet 18.

It will be appreciated that many other embodiments of the invention may be possible without departing from the spirit or scope of the invention as set out in the consistory clauses.

Dated this 6 day of March 2001

Patent Attorney / Agent for the Applicant

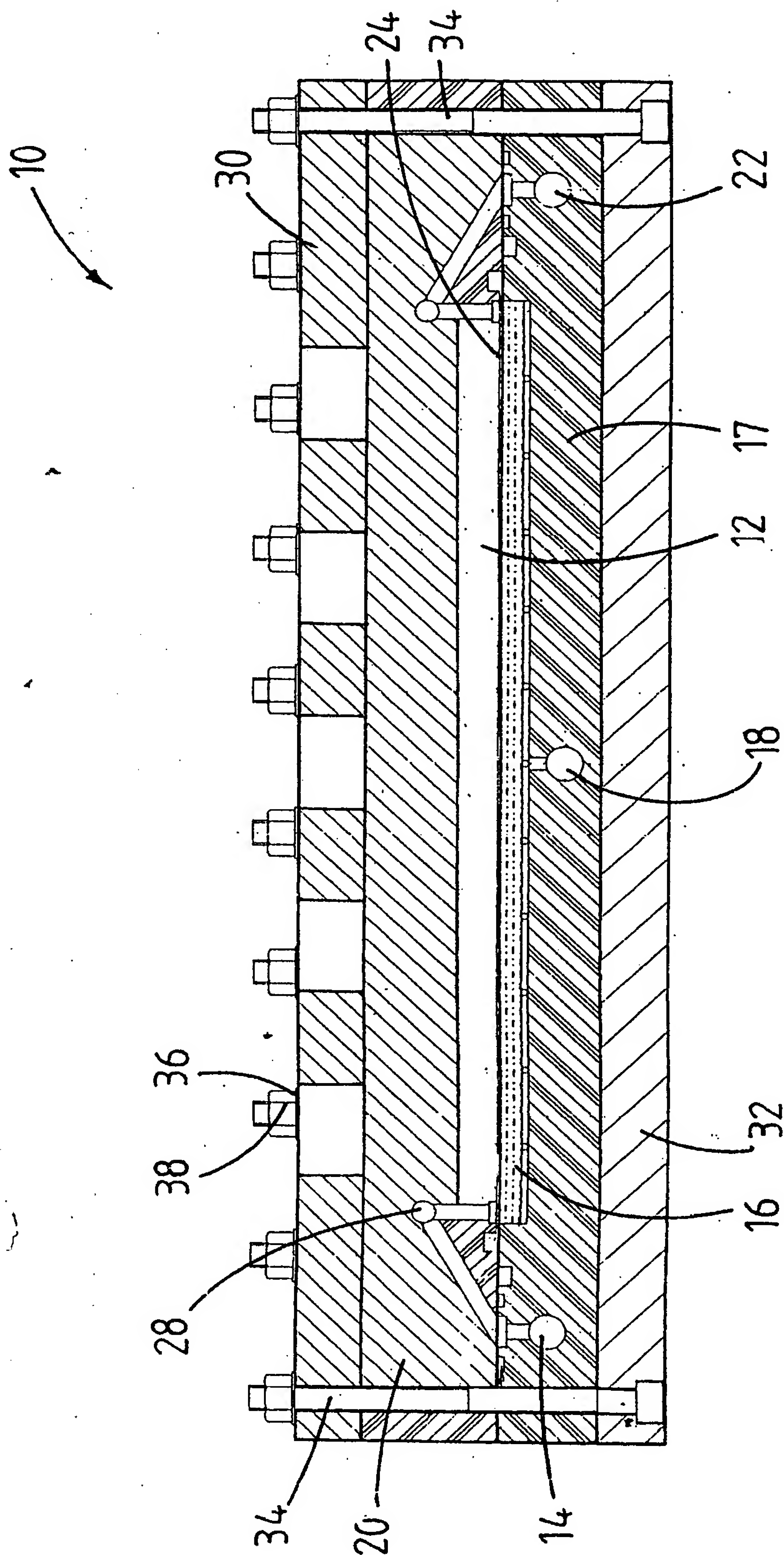


FIGURE 1

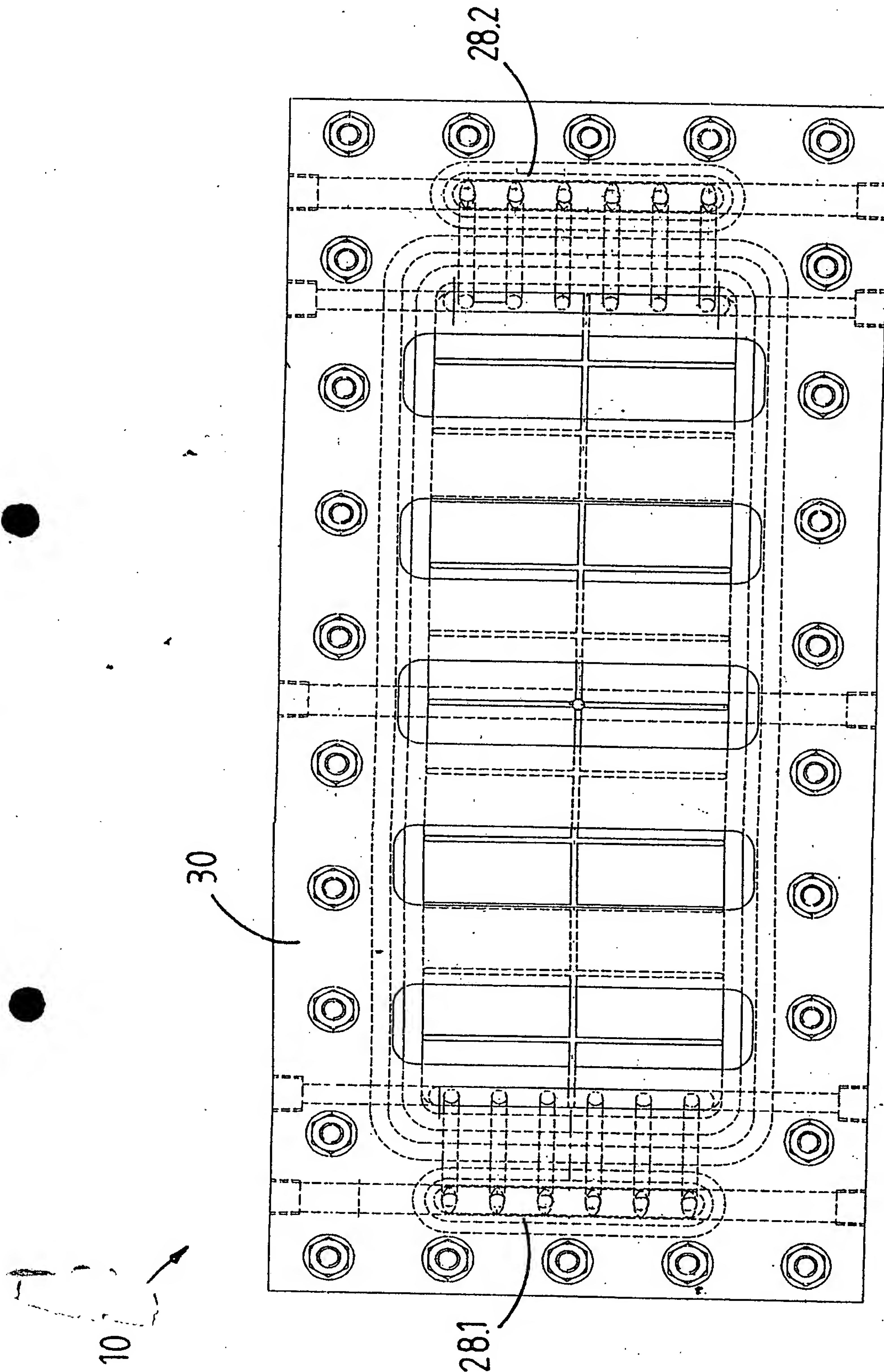


FIGURE 2

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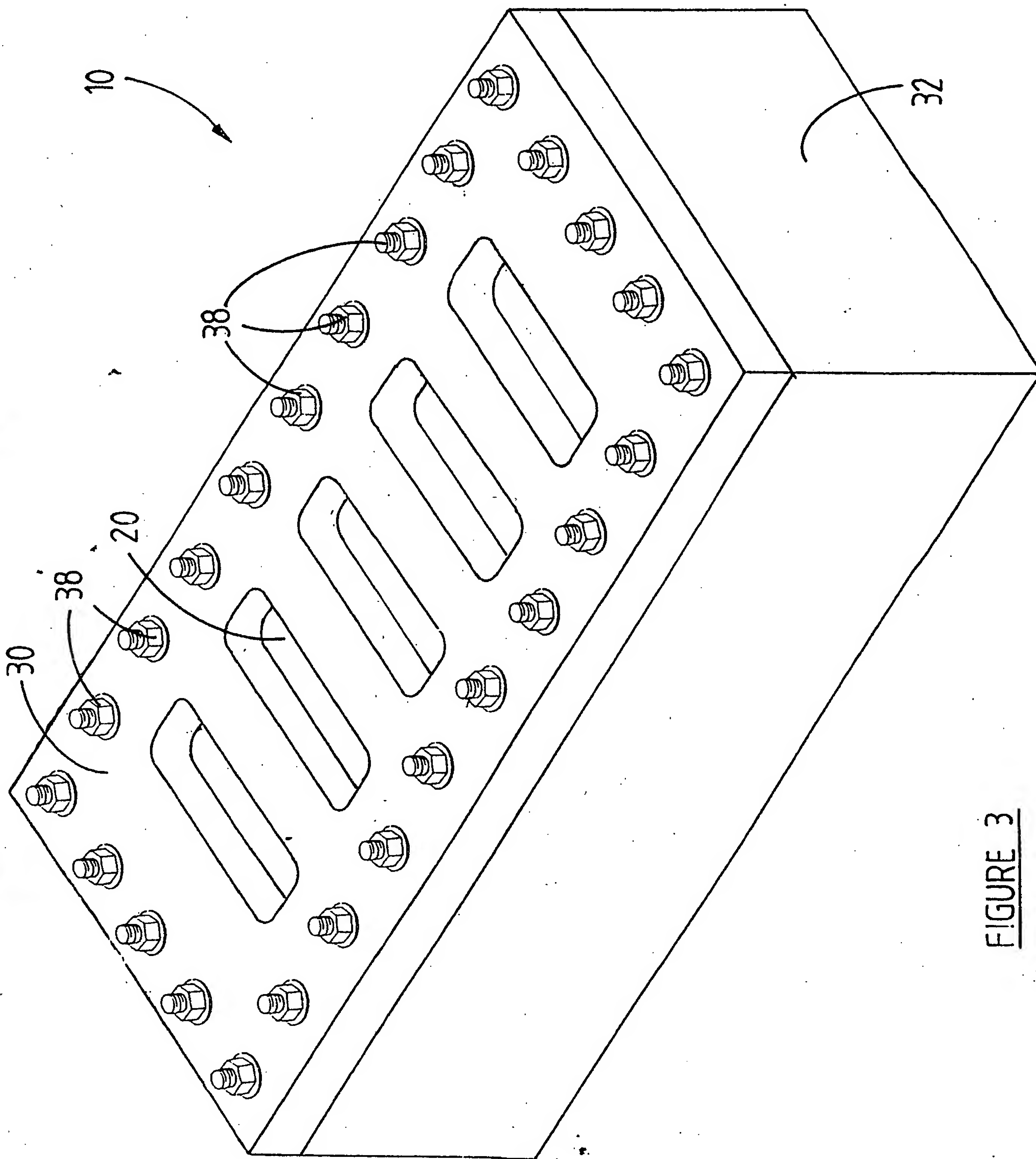


FIGURE 3